DELINEATION OF THE ROMPIN RIVER BASIN AND NETWORK USING VARIOUS GIS APPLICATIONS

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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ABSTRAK

Lembangan Sungai Rompin terutama di rantau hilir sangat sensitif terhadap banjir monsun atau banjir kilat. Kawasan-kawasan banjir sangat bergantung kepada ketinggian puncak di lembangan di mana tanah rendah lebih cenderung dipengaruhi. Oleh itu, ini sangat penting untuk mengekstrak ciri-ciri fizikal lembangan untuk disepadukan dalam analisis banjir. Objektif kajian ini adalah untuk menggambarkan rangkaian sungai dan tadahan untuk Lembangan Sungai Rompin menggunakan aplikasi GIS yang berbeza, dan menilai prestasi aplikasi GIS. Digital Elevation Model(DEM) dengan resolusi 30 m telah digunakan dalam kedua-dua alat aplikasi GIS (ArcGIS dan QGIS) untuk penambatan rangkaian sungai dan lembangan. Proses penggalian termasuk penyejukan rangkaian sungai, proses penyisihan menGISi, proses pengumpulan aliran, proses pengekstrakan rangkaian saliran dan proses pengekstrakan aliran sungai. Rangkaian sungai simulasi dari ArcGIS dan QGIS telah dinilai dan dibandingkan dengan rangkaian sungai digital dari peta Google untuk persembahan mereka. Ciri fizikal dari dua alat aplikasi GIS telah dibandingkan dan diteliti dalam kajian ini. Bagi kawasan lembah sungai, ArcGIS mempunyai 4185 km^2 kawasan dan QGIS mempunyai 4234 km^2 kawasan. Perimeter lembangan sungai untuk ArcGIS adalah 651 km, sementara QGIS mempunyai 718 km perimeter. Ketinggian minimum untuk ArcGIS dan QGIS adalah -16 dan 2 masing-masing, manakala untuk ketinggian maksimum untuk ArcGIS dan QGIS adalah 988 dan 804. Untuk ciri-ciri sungai, ArcGIS mempunyai 771 stream, manakala QGIS mempunyai 93 stream. Peratusan kesilapan purata bagi tiga ketinggian yang berbeza telah dinilai dan dibahagi kepada ketinggian yang tinggi, ketinggian pertengahan dan ketinggian yang rendah. Untuk ArcGIS, nilai yang diperolehi untuk ketinggian tinggi, pertengahan dan rendah adalah 188m, 240m dan 470m, manakala untuk QGIS, nilai yang diperolehi untuk ketinggian tinggi, pertengahan dan rendah adalah 217m, 446m dan 485m. Membandingkan keputusan yang diperoleh daripada ArcGIS dan QGIS dengan rangkaian sungai digital, didapati bahawa aplikasi ArcGIS dapat menggambarkan rangkaian sungai dengan lebih tepat pada ketinggian yang tinggi dan pertengahan, sementara QGIS hanya boleh melakukan lebih baik pada ketinggian yang tinggi. Walaupun QGIS boleh dimuat turun secara percuma dari laman web, namun ia hanya boleh berfungsi dengan baik pada ketinggian yang tinggi. Oleh kerana masalah banjir biasanya berlaku di ketinggian yang lebih rendah, QGIS mungkin tidak mencukupi untuk digunakan untuk menggambarkan rangkaian sungai pada tahap yang lebih rendah dalam kajian ini.

ABSTRACT

Rompin River Basin especially at the downstream region is highly prone to monsoon flood or flash flood. Flooding areas are closely depending on the topographical elevation in the basin where lower ground is more likely to be affected. Thus, it is essential to extract the physical characteristics of the basin to be integrated in flood analysis. The objectives of this study are to delineate river networks and catchment for the Rompin River Basin using different GIS applications, and evaluate the performance of the GIS applications. Digital Elevation Model (DEM) of 30 m resolution was applied in both GIS application tools (ArcGIS and QGIS) for the delineation of the river network and basin. The delineation processes include river network conditioning, fill sink process, flow accumulation process, drainage network extraction process and watershed basin extraction process. The simulated river network from ArcGIS and QGIS were evaluated and compared with the digitized river network from Google map for their performances. The physical characteristics from two GIS application tools were compared and tabulated in this research. For the area of the watershed basin, ArcGIS has an area of 4185 km^2 and QGIS has an area of 4234 km^2. The perimeter of the watershed basin for ArcGIS is 651 km, while QGIS has a perimeter of 718 km. The minimum elevation for ArcGIS and QGIS are -16 and 2 respectively, while for the maximum elevation for ArcGIS and QGIS are 988 and 804. For the river attributes, ArcGIS has around 771 attributes, while QGIS has around 93 attributes. The average error percentage for three different elevation has been evaluated which are high elevation, intermediate elevation and low elevation. For ArcGIS, the value obtained for high ,intermediate and low elevation are 188m, 240m and 470m, while for the QGIS, the value obtained for high ,intermediate and low elevation are 217m, 446m and 485m. Comparing the result obtained from ArcGIS and QGIS to the digitized river network, it is found that ArcGIS application can delineate the river network more accurately at the intermediate and high elevation, while QGIS can only perform better at high elevation. Although QGIS can be download for free on website, however it can only perform well on high elevation. Since the flood problem is normally occur in lower elevation, QGIS may not be sufficient to be used to delineate the river network at lower level in this study.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

µ	Mean value
n	Population size

LIST OF ABBREVIATIONS

DID	Department Of Irrigation And Drainage
GIS	Geographic Information System
ASTER	Advanced Spaceborne Thermal Emission And Reflection Radiometer
DEM	Digital Elevation Model
DTM	Digital Terrain Model
DSM	Digital Surface Model
GRASS	Geographic Resources Analysis Support System
HMS	Hydrologic Modelling System
IFSAR	Interferometric Synthetic Aperture Radar
LIDAR	Light Detection And Ranging
NASA	National Aeronautics And Space Administration
RRB	Rompin River Basin
SRTM	Shuttle Radar Topography Mission
USGS	United States Geological Survey

CHAPTER 1

INTRODUCTION

1.1 Background

Natural disasters such as floods are happening more frequently due to climate change (Ghani, et al., 2012). Climate variability of a region is often difficult to predict and hence causing it impossible to completely mitigate flood problems. In Malaysia, two types of floods that hit this country in a yearly base are flash flood and monsoon flood. Flash flood is caused by high intensity rainfall in a short period and generally occurs in high imperviousness urban area. Meanwhile, monsoon flood is caused by the seasonal rainfall that takes place during October to March.

Floods in Malaysia occurred in many areas regardless of the topographical characteristic. Rompin District is one of the area that is frequently affected by flood particularly during the monsoon season. The most recent monsoon flood as reported by (DID, 2018) occurred in January 2018. Total area affected by the monsoon flood was about 12.5 km^2 with flood depth between 1 m to 4.5 m. Five river levels were observed to be at the warning level, namely the Sungai Kurnia at Kampung Kurnia (1.96m), Sungai Puteri at Kuala Rompin (2.03m), Sungai Rompin at Kampung Kerpal (2.18m), Sungai Aur at Kampung Aur (14.60m) and Sungai Keratong at Bukit Serok (21.82m). The flood was caused by heavy rainfall, river overflow and clogging of the drainage system. Besides monsoon flood, flash flood also occurred in the Rompin District in the early January of 2018 covering a total area of 1 km^2. The flood depth recorded was 0.4 m. The main causes of the flash flood event are heavy rainfall and clogging of the drainage system.

Since flood problems imposed serious damaged to the society, it is essential to establish a mapping system indicating the prone areas for future urban planner.

Mapping is very useful to identify and demarcate potential flood area based on physical and topographic characteristic. Traditionally, topographical map was used to study the characteristics of the area of interest (Kumar & Dhiman, 2014). The watershed area was drawn in reference to the contour map and the highest points of the contour were linked to generate the model boundary (Visharolia, et al., 2017). This process is time consuming and a good quality of topographical map is needed. With the fast development in the technology nowadays, researcher and water manager have migrated from adopting the manual method to the digitalized technology in analyzing and visualizing topographical information. The digitalized topographic dataset of the Earth's surfaces is represented by Digital Elevation Model (DEM) . Information such as topographic properties, geomorphometric parameters, morphometric factors or terrain data can be extracted from the DEM dataset (Donia, 2009). In this research, DEM resolution of 30 m was used to delineate the watershed basin and river network (Arbind & Madam, 2017).

DEM dataset was applied in Geographic Information System (GIS) for analysis. Geographic Information System (GIS) is the computer-based tool which served as a framework to collects, manages, analyses, and visualizes data related to the position of the Earth's surfaces (Vinayak, et al., 2019). GIS tool is simple to utilize and has an effective geo-processing capacities which make it less demanding to visualize, oversee, analyze, alter and compose printable maps. Furthermore, GIS tool processes spatial information effectively and supports both vector and raster layers (Chandra Bose, et al., 2012). There are several open-source GIS software including QGIS, SAGA GIS, gvSIG and others available for watershed delineation. The GIS applications selected in this study are QGIS and ArcGIS in order to compare the accuracy and the efficiency of the software. One of the most important applications of GIS is the ability to delineate river basin & river network (Kaviya, et al., 2017).

Delineation of the river basin is one of the important part in solving flood problems and developing better water resources management (Mudler , 2011). Floods traditionally are predicted using hydrological watershed modeling, in order to achieve the design discharge and calculate water surface elevations and terrain analysis to produce a flood map (Jung & Merwade, 2015). In this study, the Rompin River Basin was delineated from DEM 30 m resolution using two different GIS software. The simulated river network results obtained were validated by comparing the error percentage in reference to topographical map & google satellite images. The results obtained for the delineated basin & river network can be utilized as the input topographic and hydrologic datasets for the hydrological study in water resource management work.

1.2 Problem statement

The Rompin River Basin is a highly potential flooding area due to monsoon or flash flood. In water resources management study, geographical information is important to identify the elevation of the land surfaces. Since Rompin River Basin has an area around 4285 km^2, it is difficult to delineate the river network by using manual method. This is because manual delineation processes can be very time consuming particularly in collecting and managing river network and hydrological information (Kumar & Dhiman, 2014). Thus, new technology is required to fasten the delineation process. With the rapid development of computerized technology, there are several software available capable in speeding up the delineation process. One of the applications that can be implement in this study is GIS application.

Different GIS software provides different levels of accuracy of the data. Generally, flood problems often occur at low lying area. In order to obtain sufficient information, GIS software plays an important role in data collection. Thus, there is a need to validate the DEM resolutions that generated by the different GIS software so that the performance limit of the GIS software can be defined. This helps to improve the quality of the extracted catchment physical characteristics by selecting the suitable application to delineate the watershed basin and river network.

1.3 Objectives

This study aims to:

- To delineate river networks and catchment for the Rompin River Basin using GIS applications.
- To evaluate the performance of GIS applications.

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